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DEVELOPMENT OF ADDITIVE TECHNOLOGIES

Abstract. *At the present time, additive technologies are one of the most dynamically developing areas of «digital» production. These technologies are already actively used in some areas of production. However, there are limitations that prevent the penetration of additive technologies into the wider market. This article discusses the main advantages and limitations, as well as some of the latest trends in the development of additive technologies.*

Keywords: *technology development, additive technologies, limitations, advantages, latest trends.*

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РАЗВИТИЕ АДДИТИВНЫХ ТЕХНОЛОГИЙ

Аннотация. *На данный момент аддитивные технологии - это одно из наиболее динамично развивающихся направлений «цифрового» производства. Данные технологии уже активно используются в некоторых сферах. Однако существуют ограничения, препятствующие проникновению аддитивных технологий на более широкий рынок. В данной статье рассматриваются*

основные преимущества и ограничения, а также некоторые из последних тенденций в развитии аддитивных технологий.

Ключевые слова: *развитие технологий, аддитивные технологии, ограничения, преимущества, последние тенденции.*

Additive technologies are technologies of layer-by-layer building up and synthesis of objects. They are widely used for fabber technology («3D printing»). It is a group of technological methods for the production of products and prototypes based on the step-by-step formation of a product by adding material to the base (platform or blank).

In the early 1980s, new methods of the production of parts began to develop, based not on the removal of material, but on the layer-by-layer production of a product according to a three-dimensional model obtained in a CAD (Computer-Aided Design System), by adding material in the form of plastic, ceramic, metal powders and their bundles thermal, diffusion or adhesive method. Charles Hull is a co-founder, the executive vice president and chief technology officer at 3D Systems. In 1984 he patented the first stereolithographic three-dimensional printer.

Over the course of three decades, technology has moved from making paper and plastic prototypes to directly producing functional finished products. Modern printers are capable of working with engineering plastics, composite powders, various types of metals, ceramics and sand. Additive technologies are actively used in mechanical engineering, industry, design, medicine, foundry and many other areas.

Additive manufacturing has three concepts of a revolutionary idea: universal, practical and efficient and, thus, conventional manufacturing begins to give way to these new technologies [1].

The development of additive technologies is becoming relevant. Additive manufacturing technologies have made a significant leap due to the rapid improvement of computer technology and software. At the present time, additive technologies are one of the most dynamically developing areas of «digital» production. Additive technologies are at the stage of growth in the innovation cycle, which is ensured by the

economic feasibility of their application in terms of productivity, accuracy, and quality of manufactured products. The existing limitations that prevent the introduction of additive technologies are gradually easing, so it is necessary to assess the prospects for the development of additive technologies.

The purpose of this research is to determine the forecast for the development of additive technologies for the next ten years.

Additive technologies were used only for prototyping, which was used in research and development activities. With the improvement of their basic characteristics such as productivity, accuracy, material consumption, additive technologies have been used for the manufacture of products in mechanical engineering and instrumentation, as well as in such industrial sectors as aerospace, biomedical, automotive.

In the ISO / ASTM 52900 standard, additive manufacturing is defined as: «a process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies» [1]. The ISO / ASTM 52900 standard classifies additive manufacturing in seven process categories: binder jetting, directed energy deposition, material extrusion, material jetting, powder bed fusion, sheet lamination and vat polymerization. Some of the mostly used technologies include fused deposition modeling (FDM), laminated object manufacturing (LOM), stereolithography (SLA), selective laser melting (SLM) and selective laser sintering (SLS) [1]. Current AM technologies cover solid, liquid, powder and hybrid of liquid-powder printings [2].

The design freedom offered by AM has its advantages and disadvantages from the industrial perspective. One of the main advantages of additive manufacturing is the possibility to obtain pieces of geometric complexity that could not be manufactured with traditional technologies without an elaborated configuration of the machine or a final assembly before [1]. The clear advantage in terms of environmental impact, is the reduced wastage of material and resource efficiency [3]. AM machines offer production flexibility; the machines do not require expensive set-up arrangements, making the technology economical for smaller batch production [2]. Despite the

dynamic development and significant advantages of additive technologies, there are limitations that prevent the penetration of these technologies into the wider commercial market. One of these limitations is the problem of quality assurance and quality control. The vast capability of AM, referring to material variety and manufacturing process differentiation, has resulted in multifaceted quality requirements and standards. The complexity of each system makes it difficult to develop a standard set of rules, which leads to slow development of quality assurance strategies [3]. Limitations also include the fact that AM is still a significantly expensive investment compared to traditional production machines. Entry level printers begin at around US$150, these are rudimentary small bed FDM prototyping personal use printers. However, production level printers can range from US$5,000 to near US$1,000,000 [3].

The pieces produced by additive manufacturing have limitations in the surface finish, which is relatively high when comparing to conventional manufacturing processes such as machining [1].

Some materials used in 3DP, such as ABS, PLA and nylon, can generate health hazards in the form of volatile organic compounds such as styrene, cyclohexanone, butanol, and ethylbenzene. For this reason, it is necessary to develop recommendations for production safety and conduct further research aimed at developing safer materials [4].

Hybrid machines that combine additive manufacturing with conventional technologies, such as machining have been developed in the last years. The hybrid methods of additive and subtractive manufacturing processes use an additive process to build a near-net shape that will then be machined to its final shape obtaining the desired accuracy [1]. This technology allows to combine the advantages of both technologies.

Bioprinting is an important research topic. 3D printers now have the ability to create multi-materials systems. These processes allow the construction of parts benefited by properties of different materials. The combination of additive manufacturing and biomaterials is promising for applications that concern human

health and quality of life [1]. Meta-biomaterials are developed for the creation of orthopedic implants and bone replacement.

To overcome the problem of quality assurance of additive technologies, it is necessary to implement control and monitoring systems. The AM board has developed strategies for quality inspecting individual aspects of an AM process through the use of the following test methods; Chemical analysis, Mechanical Testing, Performance Evaluation, Metallurgical Analysis, Powders Evaluation and NonDestructive Testing (NDT) [3].

The current state of additive technologies is studied in the paper. Basic information about additive technologies are considered. The main advantages and main limitations of this technology are discussed. Some of the latest trends have been summarized. Additive manufacturing is developing rapidly, complementing and sometimes even replacing traditional manufacturing. This technology has a number of significant advantages over the subtractive production method and has already been successfully used in some industries with a small production volume. However, there are limitations that prevent the penetration of additive technologies into the wider market. Therefore, it is necessary to conduct further research on possible ways to develop additive technologies and on the possibility of removing current limitations.

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